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INSUFFICIENT PROVISION FOR COUNTER-STRESSES IN RAILROAD BRIDGES.

By HENRY S. PRICHARD, M. Am. Soc. C. E.

PRESENTED SEPTEMBER 20TH, 1899.

WITH DISCUSSION.

Many specifications for railroad bridges do not make sufficient provision for counterstresses. The term counterstresses must be understood, in what follows, to apply, not only to the stresses in the counters, but to all stresses from the action of the combined dead and live loads (including the effect of shock, sudden application, etc.), which are of a reverse character to the stresses from dead load alone.

In a good modern specification the unit stresses allowed are so low that, except for the counterstresses, a bridge designed and built in accordance therewith could reasonably be expected to be able to carry without serious injury a live load at least twice as great as the live load specified.

In view of the great increase which has been and is now taking place in the weights of locomotives and trains, not to mention other pertinent considerations, the wisdom of requiring this seeming surplus of strength will hardly be questioned, yet, as regards counter-

stresses, many otherwise good specifications make no such provision for increased loads.

This defect is probably due in most cases to the failure of the authors of the specifications to realize that a provision for possible increase in loading, which is adequate for all other stresses, may be entirely inadequate for counterstresses.

To assist in the consideration of this subject, the relations between loads and stresses are stated as follows:

Calling L the live-load stress, D the dead-load stress, A the sectional area, and S the stress per square inch, then for counterstresses $S = \frac{L - D}{A}$; for stresses other than counterstresses $S = \frac{L + D}{A}$.

From these equations the following propositions are evident:

For stresses other than counterstresses, if the live load is doubled, the stress per square inch cannot be more than doubled, so that if for the original live load the stress per square inch was less than half the safe stress, the stress per square inch would still be within safe limits if the load was doubled.

For counterstresses any increase in the live load must make a greater proportional increase in the stress per square inch. If the live-load stress is but slightly larger than the dead-load stress, then even a small increase in the live load may make a very large increase in the intensity of the counterstresses, while if the live load is slightly smaller than the dead load, a small increase in the live load may require counters where none were required under the original live load.

If the counterstresses in a bridge are obtained by simply subtracting the dead-load stresses from the reversed stresses for the specified live load, and the members subject thereto are proportioned by the specified stress per square inch, which is the way prescribed in many specifications, and a common practice among bridge designers, then such members will have a less factor of safety as regards increase in the live load than the other members of the bridge, and the trusses may in some panels have no proper provision whatever for any increase in the live load.

The absence of a regular provision for counterstresses does not necessarily result in immediate failure if the bridge is subjected to a load sufficient to produce counterstresses, as the stiffness of the chords and floor system, and the fact that the load is generally but a few

moments in the critical position which would produce the counterstresses may save a bridge from seemingly impending failure.

A case in point, brought to the author's attention about a year ago, is that of a 300-ft. span, shown in Fig. 1. This span, for an unknown period, had been carrying loads which, for want of counters, would temporarily buckle the main diagonals "*A*," whenever a loaded train crossed the bridge.

As this bridge is of a common type, and has no special features or unusual stiffness in the chords and floor system tending to supply the place of counters, it is fair to suppose that most bridges would possess some capacity for sustaining loads if some of the counters necessary to a proper design were omitted. It is to be feared, however, that loads so carried produce dangerous strains in the chords and floor system which may in time cause failure. Ability to carry loads when there is not proper provision for the counterstresses, like the ability to resist stress after the elastic limit has been exceeded, is a very desirable property in a bridge, and may, in an emergency, save it from disastrous failure, but it should not be relied on for sustaining the traffic, either present or prospective.

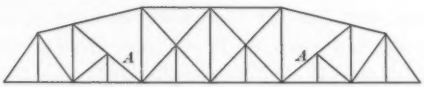

FIG. 1.

As a bridge designed in accordance with recognized good practice would be considered fairly safe as regards all stresses other than counterstresses, under increasing traffic up to a point where the live load was about double that originally specified, to be consistent, proper provision should be made for the counterstresses produced by a live load of at least double that originally specified. If the stresses are obtained from double the live load, the stress per square inch in members not subject to counterstresses will vary from something less than twice the specified stress per square inch in some members to nearly or quite twice the specified stress in others. Hence, it would seem to be consistent, after obtaining the counterstresses from double the specified live load, to allow nearly double the specified stress in proportioning.

All the previous references to live-load stresses are intended to be references to the live stresses, with the effect of shock, sudden applica-

tion, etc., included. The author's present practice in determining what members of a bridge are liable to counterstresses, and in proportioning them, is to add to the nominal live-load stresses (that is, the live-load stresses with the effect of shock, sudden application, etc., neglected), 125%, to combine the stresses thus increased with the dead-load stresses, and to use double the specified stress per square inch in determining the sectional area required.

Fortunately, even when the specifications require no provision for counterstresses beyond what would be produced by the specified live load, most bridge designers will make some provision, which, however, will differ greatly according to individual judgment. If the designers are contractors competing for work on a lump-sum basis, under specifications deficient as regards counterstresses, any provision they may make toward remedying such deficiency is a self-imposed handicap.

FIG. 2.

For bridges with parallel chords resting on two supports, as in Fig. 2, this handicap generally is not great, because for most cases only a few members will have counterstresses, even when the live load is doubled, and these stresses are mostly quite small; but for bridges with inclined chords, which for long and moderately long spans are now very frequently used, as in Figs. 1 and 3, the case is quite different, because the inclination of the chords decreases the dead-

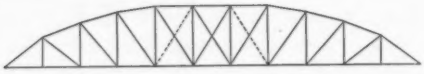

FIG. 3.

load stresses and increases the reverse live-load stresses in the web members, thus increasing the counterstresses. It is frequently customary to start the inclination of the chord at a sufficient distance from the center of the truss to avoid the use of counters in the portions of the truss having an inclined chord, and to make the inclination as great as the avoidance of counters and the maintenance of the required headroom will admit. As there is generally considerable

economy in making the inclinations of the chords as steep as possible, there is a decided advantage, from the commercial point of view of the aforesaid competing contractors, in making no provision for counterstresses in excess of the specifications.

The chief danger to be apprehended from specifications which do not make adequate provision for counterstresses lies, not in their use by those who from self-interest wilfully omit unspecified provisions which they believe to be essential to good design, but in their use by those who either fail to realize that the specifications are inadequate, or underestimate the extent of their inadequacy.

The same causes which lead engineers to write specifications which do not make sufficient provision for counterstresses may lead them to design bridges which are defective in this regard.

It is believed that what has been presented shows that provision should be made for counterstresses from some increase in the live load, perhaps more, perhaps less, than the increase advocated, and that whatever provision is decided on should in all cases be definitely and clearly stated in the specifications.

DISCUSSION.

Mr. Seaman. HENRY B. SEAMAN, M. Am. Soc. C. E.—The difficulty mentioned by the author arises from undue refinement in bridge design. The use of wheel concentrations implies that we are designing for some precise loading of the present time, while, as Mr. Prichard intimates, our designs should be an approximate provision for future conditions. The use of wheel concentrations practically submits the loading to the criticism of men who are not engineers, but who, nevertheless, exercise sufficient authority to restrict the loading. This condition would be avoided, to some extent, if a satisfactory equivalent load could be adopted.

The method suggested, of doubling the load, will avoid the difficulty described, though it seems to be rather an extreme measure. Fifteen years ago bridges were designed for 25 000-lb. concentrations, and to-day the actual concentrations in some instances reach nearly 50 000 lbs.; but this does not mean that they will reach 100 000 lbs. in the future. The larger part of the present increase took place between 1885 and 1890, and the increase since the latter date has been comparatively slight, though its adoption has been more general. The weights of locomotives having been increased about as much as the present gauge and car clearance will permit, any future increase will arise from a change of the distribution rather than from any material increase of concentration, and there seems to be no possibility of doubling the loads for which the heaviest bridges are now designed.

Mr. Jacoby. HENRY S. JACOBY, Assoc. Am. Soc. C. E. (by letter).—The subject of counter-bracing does not usually receive the attention it deserves in the design of bridge trusses. Sometimes the only rule followed is to put a counter in a panel on each side of those in which theory requires their insertion for the specified dead and live loads, without regard to the effect of impact or the future increase of loads. In some cases this may be sufficient, but in other cases the provision is wholly inadequate. This rule is certainly not a rational one.

The specification recommended in the paper is in accordance with the best practice, known to the writer, for the design of counters. The increase of 100% in the live-load stresses, besides the addition for impact, is not simply to provide for the gradual increase of the live load until it may reach that figure before the life of the bridge expires, but to provide for occasional loads of unusual magnitude, so as to avoid the necessity of shoring up bridges for such requirements, except those which may be nearing the end of their service.

As pointed out, the need for a better provision for counterstresses is greater in trusses with curved chords than for those with parallel horizontal chords. It seems that some account should also be taken

of the stresses due to the overturning moment of the wind, for a reversal of stress due to insufficient counter-bracing caused by the wind in conjunction with the live load may be just as serious in its results as if it were caused entirely by the live load. Mr. Jacoby.

Under the usual specifications, the stress due to the wind may be neglected in the design of any member unless its magnitude exceeds a given percentage of the dead plus live-load stresses, its character being the same. When, however, the character of the wind and live-load stresses is different from that of the dead-load stress it may require but a relatively small amount of the wind stress to cause a reversal of stress, and this fact often escapes notice on account of the too prevalent custom of failing to compute any minimum stresses.

Again, the addition of a counter-brace in a panel may, in turn, not only modify the magnitude of the minimum stress in an adjacent vertical, but may actually change the character of that stress, and thereby affect its design to a greater or less extent.

F. C. KUNZ, M. Am. Soc. C. E. (by letter).—The fact that the counters are the weakest members of a bridge is justly claimed as one of the reasons for the preference of those specifications which, contrary to the fatigue formulas, assume a constant unit stress and add to the live load a certain percentage for the effect of impact. This percentage varies inversely with the loaded length, and is, therefore, greater for the counters than for the main diagonals, and greater for the latter than for the chords. The result is that the counters are comparatively heavier than the other members of the truss, and are sometimes necessitated in panels in which the fatigue formulas would not call for their use. It is evident that a portion of this percentage for impact can be considered as an increase of the live load itself, as long as we reduce the impact, for instance, by reducing the velocity of the live load, thus bringing the latter nearer to a static loading. The result would be, however, that the different members of the bridge would be subjected to different unit stresses. This is allowable for small variation of the live load, but, in the last few years, the increase in the weight of the rolling load has been extraordinary, as the following figures will show. In the beginning of this decade a great number of bridges were in service which were designed originally for a live load consisting of two engines of 55 tons each, followed by cars weighing 20 tons each, while the new specifications of that time called for a live load consisting of 100-ton engines and cars of 40 tons. At the present time, most railroads specify engines weighing 120 up to 175 tons (Lehigh Valley Mountain Engine) and cars weighing up to 50 tons and more, and there is no indication that the limit has been reached. Mr. Kunz

In 1895, when the Pencoyd Iron Works were building a great number of bridges for the Missouri, Kansas and Texas Railway, they allowed

Mr. Kunz. in their designs—"Pencoyd Standards"—for a future increase of the live load in the following manner:

The unit stress of the Pencoyd Specifications for soft steel is 15 000 lbs. per square inch, but there is no reason why the material could not be stressed to two-thirds of the elastic limit, *i. e.*, 20 000 lbs. per square inch if necessary. It was determined what increase of live load, considering the impact, corresponded to an allowable unit stress of 20 000 lbs. per square inch in the chords. This increase depends, of course, on the ratio of the dead load to the sum of the live load and the percentage for impact, and is a minimum when the dead load = 0, in which case it is 33 per cent. The chords were selected because of their considerable weight, amounting to about one-half of the whole truss, and because they are, of all the truss members, affected the least by an increase of the live load, since the ratio of the approximately constant dead-load stress to the stress caused by the varying live load is the greatest. For ordinary plate-girders the allowable increase was found to be 35 to 38%; for a 100-ft. lattice girder, 40%; for a 150-ft. pin bridge, 41%; and for a 250-ft. pin bridge, 45 per cent. As an average, 42% was assumed, and, with a live load increased by this amount, with the corresponding percentage for impact and a unit stress of 20 000 lbs. per square inch, the web members and the floor were proportioned. This, of course, is exact only when the wheel spacing and the ratio of the wheel loads would remain the same.

The resulting increase in sections was comparatively small, and, as a rule, affected only the diagonals and counters, the floor and the connections, and in some cases necessitated the use of extra counters. For the details, unit stresses increased by one-third over their amount otherwise allowed have been used.

The Pennsylvania Railroad Specifications of 1897 contain a similar clause; it allows for 100% increase of live load and a unit stress of 30 000 lbs. per square inch, respectively, twice the unit stress otherwise allowed.

It is interesting to note that in Europe, although specifications using a percentage of the live load for impact which varies with the loaded length have been proposed (by Professor Melan, 1893), they have not been officially recognized as yet; some of the railroads using a more or less changed Launhardt-Weyrauch formula (France, Switzerland and part of Germany), others using a higher unit stress for longer spans than for shorter ones, but making no distinction between different members or between dead or live-load stresses (Prussia, Austria, Russia), and, again, others increasing the live-load 25 to 50%, irrespective of truss member or length of span (Prussia, Bavaria, Saxony). The most elaborate instructions concerning the proportioning of diagonals have been given in a circular of July 21st, 1899, by the Prussian Minister of Public Works:

First, where diagonals capable of tension only are used, provide counters in every panel in which a live-load increased by 50% reverses the stress of the main diagonal, the section as well as the number of connecting rivets of all the counters to be made the same as for the counters for the middle panel or panels. The counters are to be put in place after the bridge is swung, the holes for the connecting rivets on one end to be drilled in the field in such a manner as to give an initial tension. Mr. Kunz.

Second, when stiff diagonals are used the counter stresses have to be determined with the original live load (without any increase), but, in proportioning the diagonals, the stresses of which can be reversed, use throughout the counter stress of the diagonals of the middle panel or panels, assuming only one diagonal as acting.

IRA O. BAKER, M. Am. Soc. C. E. (by letter).—In submitting the following, the writer has the feeling that possibly it is too elementary and too nearly self-evident to warrant its presentation in this place. However, since no treatise on bridges, which is known to the writer, even mentions the matter, and since two computers of two of the best of the smaller bridge manufacturers certainly do not know of the method, it will be briefly stated. The writer has used this method in his class-room for over twenty years. Mr. Baker.

In finding the stresses in the web members of a railroad bridge, due to a uniform load, it is apparently the custom to use the same load, whatever the proportion of the span covered, regardless of the fact that the equivalent uniform-load corresponding to the ordinary train increases as the length of load considered decreases. For example, assume that it is proposed to find the web stresses in a six-panel, 120-ft. span, due to a given engine and train. The equivalent uniform load for 120 ft., according to a standard diagram, is 4 545 lbs. per lineal foot of track; and this is the load to be used in finding the stress in the inclined end post. To produce a maximum in the tie in the panel next to the end, the load should cover four panels, or $4 \times 20 = 80$ ft. The equivalent uniform-load for 80 ft. is 4 650 lbs. per foot, and this load should be used in finding the stress in the tie in the second panel. Similarly, the load for the third panel is 5 050 lbs. per foot, and for the fourth panel 5 670 lbs. per foot.

If the writer is correct in his belief that the above method is not generally used, then when the maximum web stresses are computed by using an equivalent uniform-load, they are generally less than the actual stresses, and the difference is greater in the counterstresses than in the main stresses.

HENRY S. PRICHARD, M. Am. Soc. C. E. (by letter).—The writer does not share Mr. Seaman's belief that an intimate connection exists between insufficient provision for counterstresses and the use of wheel concentrations in designing bridges. At any rate there is nothing to Mr. Prichard.

Mr. Prichard. prevent those who prefer the use of wheel concentration from having sound judgment regarding the proper provision for counterstresses. It may be that the present loads will not be greatly increased in the future, but the author cannot agree with Mr. Seaman that there seems to be no possibility of doubling the loads for which the heaviest bridges are now designed. At any time during the past 15 years there have been those who thought that the increase in loading had reached its limit. If the limit has now certainly been reached, then the provision proposed for counterstresses would probably be greater than necessary, but so also would be the provision generally made for all the other stresses.

As Professor Jacoby points out, an increase of 100% in the live-load stresses, besides the addition for impact, is not simply to provide for the gradual future increase of loads. It is in reality a factor of safety against any contingency in which the effect of the load on counterstresses is greater than would be anticipated from the normal loading. The author would not consider it wise to make this factor of safety as low as 42%, as Mr. Kunz stated was done in the cases he cites of bridges for the Missouri, Kansas and Texas Railway. If, in those bridges, the effect of the load was, from any cause, slightly more than 42% in excess of what would be anticipated from the normal load, then, as regards all stresses other than counterstresses, the effect would simply be to increase the stresses to slightly over 20 000 lbs. per square inch; but, for counterstresses, the effect might be to put counterstresses where no provision whatever has been made for them.

The writer prefers the provision cited by Mr. Kunz as given in the Pennsylvania Railroad Specifications of 1895. This provision, which consists of doubling both the live load and the allowed unit stress, was made at the writer's suggestion, after a preliminary draft of the specifications had been submitted to him for criticism.

Mr. Kunz's synopsis of European practice is interesting, but the instructions by the Prussian Minister, to which he refers, seem to be more complicated than scientific.

The influence of the wind in reversing stresses should be considered, as stated by Professor Jacoby, but, as the maximum wind pressure, in combination with the other conditions which tend to reverse stresses, does not occur frequently, it would seem to be justifiable, in providing for its influence, to use high unit stresses.

Professor Baker has shown conclusively that a bridge designed for a uniform load will have less provision for web stresses in general and counterstresses in particular, in comparison with the provision for chord stresses, than it would have were it designed for the usual engine and train load. While having no connection with the subject under discussion, it may be remarked, incidentally, that Professor Baker's analysis also indicates the difficult nature of the problem

which confronts those who are striving to find some simple substitute for the method of determining stresses from the engine wheel concentrations. Any one who is expert in the use of the moment diagram will find that for ordinary cases it takes less time and trouble to use the method of wheel concentrations than it would to use an equivalent uniform load if a different equivalent had to be determined for each different position of the load. Mr. Prichard.

MEMOIRS OF DECEASED MEMBERS.

CHARLES EDWARD EMERY, M. Am. Soc. C. E.*

DIED JUNE 1ST, 1898.

Charles Edward Emery was born at Aurora, N. Y., March 29th, 1838, and was educated at the Canandaigua Academy. His first work was in manufactories and in the drawing offices of railroad shops in the vicinity of his home, after which he turned, for two years, to the study of law, with the intention of becoming a patent attorney. Upon the outbreak of the Civil War, Mr. Emery organized a company of volunteers, but on the announcement that the company was not needed he sought admission to the Navy. He was appointed Third Assistant Engineer in the Navy, July 11th, 1861, and was promoted to Second Assistant Engineer, December 18th, 1862. Mr. Emery's service included blockading duty with the Gulf Squadron and various engagements with the Confederate fleet below New Orleans, battles with forts at Pensacola, Fla.; with Forts Jackson and St. Philip, the capture of New Orleans and fights with the forts at Vicksburg and Port Hudson. Following his promotion, Mr. Emery was transferred to the *Nipsic*, the first of a new class of fast gunboats, stationed in Dahlgren's fleet, off Charleston, S. C. Some suggestions made by him, as to experimental steam apparatus, led to his selection, by the Chief Engineer of the Navy, in 1864, for scientific research in the United States Navy Steam Expansion Experiments at New York. Mr. Emery's labors for the Government did not, however, cease with his resignation from the Navy in 1868, for later he served as Consulting Engineer and Chairman of the Board of Examiners of the United States Revenue Marine and the United States Coast Survey, and, dating from April, 1872, as a member of the special commission advisory to the Secretary of the Treasury in reference to the Revenue Marine service.

Following his retirement from the Navy, Mr. Emery was engaged, in 1869, for a year or more, in making, for the Novelty Iron Works in New York City, a series of experiments upon stationary engines which it was proposed to manufacture. The records of these researches were published subsequently by Professor W. P. Trowbridge, and entitled "Condensing and Non-Condensing Engines." It had been arranged that Mr. Emery should become general superintendent of the works, but, owing to a change of plans, the establishment was

* Memoir prepared by the Secretary from papers on file, and from various sources.

closed, and Mr. Emery entered into business on his own account, as a consulting engineer.

Mr. Emery served as General Superintendent of the Fair of the American Institute in New York City in the autumn of 1869, and directed the scientific work of that institution in the testing of engines and boilers. In 1876 he was appointed a member of the international jury at the Centennial Exposition, on engines, pumps and mechanical appliances, and was associate to committees on other scientific apparatus. He inaugurated an extensive series of tests of engines and boilers, and prepared extended reports of this work, which were subsequently published. In 1893, Mr. Emery was appointed one of the judges of the World's Columbian Exposition, on dynamos and motors. He served in 1884 on the committee appointed by the American Society of Mechanical Engineers, to prepare a code for steam boiler trials, and, in 1895, was made chairman of a committee to revise the code previously reported. He was engaged in the final revision of this committee's report at the time of his death.

Mr. Emery's advisory services for the National Government began in 1869, with his appointment as Consulting Engineer to the Coast Survey and to the Revenue Marine. His engagement with these branches terminated when they passed, successively, into the control of the Navy Department, in 1879 and 1891. He fitted out nearly twenty of the revenue cutters, being in some cases responsible for the construction of the hulls, as well as the machinery. His experimental work in this service, in the construction of economical engines and in the scientific determination of engine-efficiency, attracted much attention. In 1874, he was able to place three different types of machinery in three hulls of the same size: first, a long-stroke, high-pressure, condensing engine; second, a short-stroke, low-pressure, condensing engine; and third, a fore-and-aft compound condensing engine. These vessels, as well as a subsequent one, in which the cylinder of a high-pressure condensing engine was jacketed, were tested by a joint board of engineers from the Navy and Treasury Departments, and the published results of this trial, together with an analysis of them by Mr. Emery, were widely circulated and used. Soon after this, New York University conferred upon him the degree of Doctor of Philosophy.

Possibly the most notable of Mr. Emery's engagements in private practice was the work of the New York Steam Company, which he took up in 1879. This involved the generation of steam in a central plant and its distribution for heating and power purposes. In its construction, the plant was the largest of the kind attempted, and included pioneer work in many details. The design and superintendence of the construction of this plant were in Mr. Emery's charge until 1887, and, with its working, were described in a paper read before the Institution of Civil Engineers, in 1889. For that contribu-

tion, the Institution awarded him a Watt medal and a Telford premium.

Mr. Emery's practice as a consulting engineer and professional expert was extensive, and his services were in request in important legal cases. As consulting engineer for the City of Fall River, Mass., he was instrumental in bringing about a novel compromise of the difficulties between the city and the mill owners, resulting in an agreement whereby water was to be thereafter furnished to the city from the Watuppa ponds in consideration of the abatement of taxes on water power. He was a member of the commission on the purchase of the Long Island Water Supply Company's plant by the City of Brooklyn, N. Y.; was engaged in the matters of the water supplies of the cities of Newark, N. J., Lowell and Worcester, Mass.; the Holyoke, Mass., water-power tax cases, and had been consulting engineer for the Pneumatic Dynamite Gun Company. In 1887, he served as a member of the Board of Experts appointed to give an opinion as to the best method of increasing the number and size of trains on the New York and Brooklyn Bridge, by changes in the New York terminal, and at the time of his death he represented the Central Railroad of New Jersey in the matter of the Bound Brook floods.

Mr. Emery was elected a Member of the American Society of Civil Engineers May 6th, 1874. He contributed extensively to scientific literature and to the publications of the engineering societies in which he held membership. The papers by Mr. Emery published in the *Transactions* of this Society include: "Compound and Non-Compound Steam Engines, Steam Jackets, Etc.," December, 1874; "Connected-Arc Marine Boilers; Principles of their Construction," December, 1876; "Relative Quantities of Material in Bridges, of Different Kinds, of Various Heights," read at the Ninth Annual Convention, April 25th, 1877; "Steam Engine Economy," March, 1878; "Flexure and Transverse Resistance of Beams," June, 1879; "The Cost of Steam Power," June, 1883; "The Station B Chimney of the New York Steam Company," April, 1885; "A Novel Application of the Polar Planimeter," July, 1886; "Clamp for Pulling Sheet Piling," March, 1889; "Observations on the Forth Bridge," June, 1890, and "District Steam Systems," March, 1891. Mr. Emery was also a Member of the Institution of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Association for the Advancement of Science and a Fellow of the Brooklyn Institute of Arts and Sciences.

HENRY FLAD, M. Am. Soc. C. E.*

DIED JUNE 20TH, 1898.

Henry Flad was one of many men of rare ability for whose presence in America we are indebted to the Republican Revolution of 1848–49 in Germany. He was born July 30th, 1824, in the Grand Duchy of Baden, near the university town of Heidelberg. His father, Jacob Flad, dying within the same year, his mother, Francisca Brunn Flad, very soon afterward removed to the town of Speyer, a few miles distant, upon the left bank of the Rhine, in the Rhine Palatinate, a province belonging to Bavaria. After passing through the preparatory schools of Speyer, young Henry entered the University of Munich, in Bavaria, where he took the polytechnic course. Upon his graduation in 1846, at twenty-two years of age, he was given a position in the engineering service of the Bavarian Government, his first employment being on works for the improvement of the River Rhine.

The years which immediately followed, particularly 1848 and 1849, were years of great political commotion throughout Europe. Encouraged by the success of the revolution in France, which drove out King Louis Philippe, the longings of the German people for a freer and more united government found such vigorous expression that the princes of the many petty States into which Germany was divided acceded to the convocation of a National Assembly or Parliament, which, in May, 1848, met in Frankfurt to frame a constitution for United Germany. Unfortunately, the deliberations of this assembly showed such wide differences of opinion and so little ability to unite in any workable plan that the ardor of the more conservative classes began to cool. The princes seized their opportunity to reassert themselves, and repudiated the authority of the Parliament.

In Southern Germany, the champions of the Parliament took up arms in its behalf. Among them was Henry Flad, who, then in his twenty-fifth year, joined the Parliamentary army as a captain of engineers. Fortune, however, was against them, and, after several engagements, the Parliamentary army was driven into Switzerland, and disbanded. Meanwhile, its leaders were placed under the ban, and Captain Flad, with many others, was sentenced to death.

Under these circumstances he very naturally turned his face westward, took passage for the United States, and, in the autumn of 1849, landed in New York.

His first employment, after his landing, was as a draftsman in an architect's office. It was not long, however, before he entered the

*Memoir prepared by Robert Moore, Joseph P. Davis and J. A. Ockerson, Members, Am. Soc. C. E.

engineering service of the New York and Erie Railroad, then under construction, his headquarters being at Dunkirk, at the extreme western end of the road. Mr. James P. Kirkwood and Mr. James H. Morley, with whom Captain Flad was afterward associated, were also employed at this time on the same road. After the completion of the New York and Erie Railroad, in 1851, we first hear of Captain Flad as located for a time at Tonawanda, between Niagara Falls and Buffalo; and, then, in 1852, as an assistant engineer in the construction of the Ohio and Mississippi Railroad from Cincinnati to St. Louis, his headquarters being at Vincennes, Ind.

Upon the opening of the Ohio and Mississippi Railroad to St. Louis, in 1854—that being the first railway to reach St. Louis from the East—Captain Flad went to Missouri as an assistant engineer on the Iron Mountain Railroad, of which his former colleague on the Erie Railroad, Mr. James H. Morley, was the chief engineer. During the construction of this road, Captain Flad was located at Potosi, Mo. After its completion to Pilot Knob, where for a number of years it ended, he became land and tie agent of the railroad company, with headquarters at Arcadia, Mo. During this period, on September 12th, 1856, Captain Flad was married to Miss Reichard, of St. Louis.

Upon the outbreak of the Civil War, in 1861, Captain Flad came to St. Louis; and enlisted, on June 15th, as a private soldier in Company F, of the Third Regiment, United States Reserve Corps. He was soon promoted Corporal, and then Sergeant.

In July, 1861, a regiment, known as "The Engineer Regiment of the West," recruited mainly in the States of Illinois and Missouri, was organized by Colonel J. W. Bissell, and Henry Flad was made Captain of Company B. In August of the same year he was detailed by General Fremont, then in command at St. Louis, for service in the construction of fortifications at Cape Girardeau, Mo., where he remained for several months. Later in the year, when Fremont was succeeded by General Halleck, Captain Flad was ordered to join General Pope in southeast Missouri, and served as a staff officer through the campaign of New Madrid and Point Pleasant, and at the taking of Island Number Ten, after which he rejoined his regiment at New Madrid. He was with his regiment at Fort Pillow and Pittsburg Landing, and during the operations before Corinth. During the summer of 1862 he was engaged in repairing the Mobile and Ohio Railroad, in building forts at Corinth, and in repairing the Mississippi Central Railroad. He was also engaged in Grant's advance on Grenada. In February, 1863, he was ordered to Young's Point, where he was employed in engineering work, as he was later at Baxter Bayou, Lake Providence and Bayou Macon.

In April, 1863, he had charge of the repairs of the Memphis and Charleston Railroad at Memphis, Grand Junction, Jackson and

Columbus. In October of the same year he was employed in repairing the same railroad east of Corinth, under General Sherman, and was with him at Cherokee, Bear Creek and Iuka, in northern Mississippi.

Meanwhile he had been promoted on November 17th, 1862, to the rank of Major, on July 30th, 1863, to that of Lieutenant-Colonel, and on October 16th, 1863, to that of Colonel. On January 1st, 1864, at Nashville, Tenn., he was transferred, as Colonel, to the First Regiment of Engineers, Missouri Volunteers, a new regiment formed by the consolidation of the former engineer regiment and the Twenty-fifth Missouri Infantry. During the summer of 1864 he was engaged in completing the Nashville and Northwestern Railroad from Nashville to Johnsonville, and in constructing defensive works. In August he was ordered to Atlanta, and served there and in that neighborhood until about the first of November, his last work being the construction of a new line of fortifications at Atlanta.

At that time the term of enlistment of seven companies expired. The command of the remaining five companies then, under the army regulations, devolved upon the Lieutenant-Colonel, and the Colonel was mustered out November 12th, 1864, at Nashville, Tenn. His term of service had been three years and six months, during which time, with not more than a week's leave of absence, he had been constantly in the field.

Upon being mustered out, Colonel Flad returned to St. Louis, and began to look around for employment in his profession. In a short time the agitation for an improved water supply for St. Louis resulted in a State law authorizing the appointment of a Board of Water Commissioners, charged with the duty of making surveys and plans and constructing a new system of water-works for the city. Soon after the organization of the new board, in the spring of 1865, Mr. James P. Kirkwood, who had formerly been chief engineer of the Pacific (now the Missouri Pacific) Railroad, and had just completed the building of new water-works for Brooklyn, N. Y., was appointed chief engineer, and Henry Flad, chief assistant engineer.

Surveys and investigations were at once begun, and, by the end of the year, a plan was presented for new works with intake, settling basins and filter beds at the Chain of Rocks, and a distributing reservoir on what was then known as Rinkel's Hill, on Easton Avenue, near the present city limits. This plan received the approval of the Board of Water Commissioners; and, as subsequent experience has abundantly proven, was undoubtedly the best. But, besides running counter to some private interests, it involved such a large outlay and such a radical departure from the old plan that, on the part of many leading citizens, as well as the city authorities, it encountered overwhelming disapproval. The opposition finally became so great that the Water Commissioners were called upon by the City Council to resign. To

this demand they presently acceded, and, in July, 1866, a new board, committed to a new plan, was appointed. Meanwhile Mr. Kirkwood had been commissioned to go to Europe to study the subject of filtration, and Colonel Flad was left as acting chief engineer. In December, 1866, a revised plan, with intake and settling basins at Bissel's Point and a distributing reservoir on Compton Hill, substantially as afterward built, was presented.

Early in the following year, the act organizing the Board of Water Commissioners was amended, the number of members being reduced from four to three, and in March, 1867, a new board was appointed with Colonel Flad as one of its members. This position he held continuously by reappointment for eight years, or until April, 1875. During that time the new water-works were completed, and during the year 1872 were put into service.

While he was still acting as assistant engineer to Mr. Kirkwood, Colonel Flad made the acquaintance of Captain James B. Eads, who was at that time engaged upon plans for gun carriages and turrets. The rooms occupied by the Water Board being larger than they then needed, Captain Eads, upon his request, had been granted space in which to place a draftsman at work. This was followed by frequent discussions between the two men upon engineering questions, which led to a mutual recognition of each other's abilities and laid the foundation of a life-long friendship. When, therefore, in 1868, Captain Eads, as chief promoter as well as chief engineer, was ready to begin the work of constructing the great bridge over the Mississippi River at St. Louis, he very naturally tendered the position of chief assistant engineer to Colonel Flad. As the duties of the latter as member of the Board of Water Commissioners did not require all his time, this opportunity to take part in this most interesting and important work was gladly accepted, and he retained his connection with it until its completion in 1874. Some of the boldest features of this great enterprise, such as the method of erection without false work, were due to Colonel Flad.

During 1875 and 1876 he was engaged as consulting engineer in various works in conjunction with Mr. Charles Pfeiffer, who had been associated with him on the St. Louis bridge, Mr. Thomas J. Whitman, Chief Engineer of the Water-Works, and Professor Charles A. Smith, of Washington University. Among his other engagements was that of engineer for the commissioners who purchased and laid out Forest Park, St. Louis.

In the autumn of 1876, the new charter of the City of St. Louis was inaugurated, and Colonel Flad was elected the first President of the newly constituted Board of Public Improvements. This office he held continuously for nearly fourteen years, being re-elected in 1881, 1885 and 1889.

The problem to which the new Board addressed itself was that of taking the whole system of municipal public works out of the mire of politics, and placing it upon the basis of merit and fitness. Into this work Colonel Flad entered with characteristic zeal and a determination which nothing could shake. His efforts were crowned with entire success, so that during the whole period of his administration the Board over which he presided had the entire confidence of the whole community. Every citizen felt sure that in every department of the public works the city received a dollar's worth for every dollar spent, and in this respect St. Louis became a model for other cities.

In April, 1890, he resigned his office as President of the Board of Public Improvements to accept an appointment as member of the Mississippi River Commission, a position in which he remained until his death.

In November, 1891, he was appointed a member of a committee of the Commission to prepare a project for the construction of a dredge boat to be used in deepening the Mississippi River over the bars in extreme low water—a problem in which his remarkable mechanical ingenuity found a fertile field. After a most careful study of the subject in all its bearings, plans were drawn for an experimental dredge, which was built under his personal supervision.

While this experimental dredge was by no means perfect, its main features were found to meet the requirements so well that they have been embodied in all the later dredges built by the Commission, and its construction marks the beginning of a new era in the history of river improvement.

Colonel Flad became a member of the American Society of Civil Engineers on February 15th, 1871, and was President of the Society for the year ending January 19th, 1887. He was also a charter member of the Engineers' Club of St. Louis, and for twelve years, from 1868 to 1880, was its President, thus receiving from both organizations the highest honor within their power to bestow.

His death occurred June 20th, 1898, at Pittsburg, Pa., where, on his way home from a meeting of the Mississippi River Commission, he stopped to visit Mr. Godfrey Stengel, a life-long friend who, forty-nine years before, had come with him on the same ship to America. He died very suddenly of acute heart failure while walking home from one of the parks in company with Mr. and Mrs. Stengel. Up to the last moment he was in excellent spirits and died without pain, as without fear.

As an engineer, Colonel Flad was remarkable for his great fertility of invention. For every new problem he had not only one, but many solutions, and the rapidity with which he grasped all its conditions and framed his plans to meet them amounted to genius. In doing this he was not limited by precedent, but looked instinctively for new and better methods than any before known. In boldness and origin-

ality he has had but few equals in the annals of the profession. And, like the most successful workers in every field, he delighted in his work for its own sake. Nothing could exceed the interest with which he attacked a new problem, and he gave himself no rest until he had solved it. The solution once found, however, the whole subject ceased to interest him, and he passed on to something new. This trait is illustrated by the fact that, although he took out numerous patents for new and useful inventions, to their introduction and utilization he gave no thought. It was the work, rather than its rewards, for which he cared.

As a man he was equally great. His unassuming modesty, his perfect candor and simplicity, his unflinching courage, his absolute fidelity to his convictions, his single-minded subordination of personal to the public welfare—qualities which were written in every line of his face and manifested in every act of his life—all stamped him as a man of the highest type. Anyone who knew him believed in him—without limit. His name was a synonym for fidelity and skill, and all knew that every work committed to his charge would be well done and come from his hand as sound and flawless as the man himself.

This evident and perfect integrity of purpose made his public service a legacy of incalculable value to his fellow citizens. His life was a demonstration of how honorable the public service can be made, and is an encouragement to those who have not yet lost faith in the possibility of having this service in all its branches lifted to the same standard to "abate no jot of heart or hope," but still work on for the accomplishment of this high end.

To his fellows in his chosen calling, his name and example are especially precious; for in him was realized the highest ideal of the engineer—a man of trained intellect, controlled by an iron will and directed to the noblest public ends. And his success in attaining this ideal will inspire others to frame their lives upon the same noble lines.

SIR CASIMIR STANISLAUS GZOWSKI, M. Am. Soc. C. E.*

DIED AUGUST 24TH, 1898.

Casimir Stanislaus Gzowski was born at St. Petersburg, Russia, March 5th, 1813. He was the son of Stanislaus, Count Gzowski, who held a commission in the Imperial Guard, and was descended from an old Polish family, ennobled in the sixteenth century. At the age of 9 years the son was placed in the Military Engineering School at Kremnitz, and in 1830 he received a commission in the engineering branch of the Imperial service. He, in company with many other officers of his nationality, was active in the Polish insurrection of 1830-31, in consequence of which he was exiled, after several months spent in confinement in a military prison. He came to the United States and landed in New York City in the summer of 1833, a stranger to the language spoken, without friends and with but little money.

His first task was to acquire a knowledge of English. He had a command of Continental languages, and while pursuing his studies he obtained the means of livelihood by teaching French, German and Italian and by giving lessons in drawing and fencing. Removing to Pittsfield, Mass., he began the study of law with Mr. Parker Hall. He was admitted to citizenship in the United States and to the bar in Pennsylvania in 1837. He continued the practice of law for four years and then went to Toronto, with a view of securing a contract in connection with the widening of the Welland Canal.

Here he met some of the leading public men of the Dominion at that time, and Sir Charles Bagot, then at the head of the Canadian Government, formed a high opinion of his ability, and procured for Mr. Gzowski an appointment in the Public Works Department. This was the beginning of his long and distinguished career in the Dominion of Canada. For six years he was Superintending Engineer of Roads and Harbors in Western Ontario, and for three years engineer of the harbor works at Montreal and consulting engineer of the ship canal improvement between Montreal and Quebec. He became naturalized as a British subject, and in 1848 left the Department of Public Works to become Chief Engineer on the construction of the St. Lawrence and Atlantic Railway, now a part of the Grand Trunk system. He resigned this position in 1852 to enter into partnership with Sir Alexander Galt, Mr. Luther H. Halton and the Hon. D. L. Macpherson, for the construction of the Grand Trunk Railway from Toronto to Sarnia, from Port Huron to Detroit and from London to St. Mary's. In 1857 he established the Toronto Rolling Mills for the manufacture

* Prepared by the Secretary from information on file at the House of the Society.

of rails and other railway material. In 1870 he was appointed a member of a commission to inquire into the water communications of the Dominion, and in 1871 the firm of Gzowski & Macpherson constructed the International Bridge over the Niagara River. While in charge of this work, Mr. Gzowski was also called upon to report upon the enlargement of the Welland Canal and on the Baie Verte canal scheme. He was consulted frequently by the Dominion Government on matters relating to railways, canals and harbors.

Mr. Gzowski was chairman of the Niagara Falls Park Commission, one of the founders of the Canadian Society of Civil Engineers and its President for three consecutive years. He was deeply interested in military matters and in the promotion of international marksmanship contests. He rose to the rank of Colonel in the Canadian militia, and in 1879 was made an honorary aide-de-camp to the Queen. He held office in 1896, as Administrator of the Government of Ontario. In 1890, in recognition of valuable services rendered to the Dominion of Canada, he was created a Knight Commander of the Order of St. Michael and St. George.

Mr. Gzowski was elected a member of the American Society of Civil Engineers, December 2d, 1868, and served as one of its Directors during 1894.

FRANCIS RINECKER, M. Am. Soc. C. E.*

DIED APRIL 10TH, 1899.

Francis Rinecker, of Würzburg, Germany, was born December 16th, 1843. He studied mathematics and mechanical engineering under Professer F. Redtenbacher at the Polytechnic School at Carlsruhe, from 1858 to 1862, and civil engineering under Professor C. Culmann. at the Polytechnic School at Zurich, from 1862 to 1864. He began practical work in November, 1864, as assistant engineer of the Bavarian State Railways, C. Hohenner, chief engineer. He was engaged until November, 1867, in laying out and constructing part of the Munich and Ingolstadt Railway. In 1868 Mr. Rinecker traveled in Germany and France, and, coming to the United States, worked as an architectural draftsman from August of that year to April, 1869, in New York City, where he served with Charles Pfeifer, General Burger and J. Kellum. Turning to railway work in May, 1869, he was engaged successively as draftsman, assistant engineer and principal assistant of the construction department of the Pittsburg, Fort Wayne and Chicago Railway Company, and subsequently by the Pennsylvania Company, until June, 1873. Mr. Rinecker surveyed and constructed for the company first named the Erie and Pittsburg Railroad and the Ashtabula, Youngstown and Pittsburg Railroad, and conducted preliminary surveys for the Shenango Valley and Alliance Railroad, of which F. Slataper, M. Am. Soc. C. E., was chief engineer.

Returning to Europe, Mr. Rinecker served for two and a half years, from January, 1874, as Division Engineer of the Swiss Central Railway Company, for surveys and construction of the Liestal and Oensingen Railway and the Liestal and Waldenburg Railway (R. von Würthenau, Chief Engineer). From 1876 to 1883 he was engaged in literary pursuits with the especial view of introducing the rack on the St. Gothard and other mountain railways. He established in August, 1883, the firm of Rinecker, Abt & Co., at Würzburg, Germany, for the Abt system of mountain railways, and personally superintended the construction of the Lehesten & Oertelsbruch Railway and the narrow-gauge quarry tracks at Oertelsbruch and their extensions on the Abt combination system. From the establishment of this firm until his death, Mr. Rinecker had undertaken the construction of a number of Abt rack railways, including the Harzbahn in Germany, the Usui Toge Railway in Japan, the Transandine Railway, the Nilgiri Railway, the Mount Lyell Railway in Tasmania, the Mount Morgan Railway in Queensland and the Snowdon Railway.

* Memoir prepared from data furnished by Herr E. Wirsing, Würzburg, Germany.

In 1891–92 Mr. Rinecker traveled around the world, remaining in Cape Colony, New Zealand, Australia and Japan for several months. In these countries he made the acquaintance of many of the principal engineers, and studied the application of the Abt system to the conditions presented in each land. After his return he lived quietly at Würzburg, and died from influenza.

Mr. Rinecker was a member of the Institution of Civil Engineers, and was elected a Member of the American Society of Civil Engineers August 7th, 1872.

ROBERT DELOS ROWE, M. Am. Soc. C. E.*

DIED MARCH 14TH, 1899.

Robert Delos Rowe was born at Sheridan, Ill., August 24th, 1863, and received a common-school education, with an advanced course in the graded school of that place, under the tutelage of Professor F. Y. Hamilton. He went into the field as rodman on the construction of the Atchison, Topeka and Santa Fé Railroad in Kansas, in 1878, and served as inspector of bridging in New Mexico in 1879–80, narrowly escaping the Indians during the Victoria troubles of 1882. Mr. Rowe returned to school in 1883–84, and after taking an engineering course at Valparaiso, Ind., under Professor Bogart, was advanced as Resident Engineer of the New Mexico Division of the Atchison, Topeka and Santa Fé Railroad, which position he held until 1892. Removing then to Chicago, he built the South Chicago City Railway and operated it for about two years. He then engaged in private practice in the engineering profession, became junior member of the firm of Rowe & Rowe of Chicago, planned the large timber preserving works at Somerville, Tex., and also similar works for the Santa Fé Pacific Railroad at Bellemont, Ariz.

Mr. Rowe married in 1885 Miss Allie Kyger, of Mulberry, Ind., who died one year later. He married again in 1897 Miss Milla Y. Campbell, of Chicago, who survives him. His death resulted from an attack of pneumonia. Mr. Rowe was a man of high acquirements and strict integrity, and had earned the confidence of his superiors and the love of his associates and employees.

Mr. Rowe was elected a Member of the American Society of Civil Engineers January 2d, 1890.

* Memoir prepared by Samuel M. Rowe, M. Am. Soc. C. E.

WILLIAM ULYSSES SCOTT, Assoc. M. Am. Soc. C. E.*

DIED SEPTEMBER 26TH, 1898.

William Ulysses Scott was born in Hoboken, N. J., January 18th, 1870. From his schoolboy days he showed remarkable mathematical abilities, and these brought him into prominence in his studies after his removal with his parents to Chicago, Ill., which occurred when he was twelve years old.

His first engagement was in March, 1888, with the Wheeling and Lake Erie Railroad, on the preliminary survey between Bowerston and Martins Ferry, Ohio. He spent nearly two years in the service of this road, rising to the position of assistant in the Toledo office, where he was engaged in making calculations for preliminary and location estimates. In the winter of 1889-90 he was employed with John Hanlon, of Canton, Ohio, on the preliminary survey for the Toledo and Walhonding Valley Railroad, and on the survey of the canal front at Massillon, Ohio. For two periods, in 1890 and 1891, he was employed as Assistant Engineer on the maintenance of way of the Second Division of the Illinois Central Railroad, and for three months preceding March, 1891, he was transitman on the location survey of the Fort Wayne, Terre Haute and Southwestern Railway.

In March, 1892, he again entered the employ of the Illinois Central Railroad Company as Assistant Engineer of the Louisiana Division. He had charge of a variety of engineering work, including the laying out of yards and company property, the construction of the Pacific Junction incline, the Poydras elevator, survey for the Stuyvesant dock terminal, and round houses at New Orleans, La., and Canton, Miss.

Mr. Scott had edited a book of logarithms, tables and short methods of computation, and was the author of numerous tables for frogs and switches, which, though never published, have been found of service by many engineers. He was also expert in laying out and personally supervising intricate track work.

He was modest and unassuming in manner, highly esteemed by the officials of the companies he served, and popular with those persons with whom his work brought him in contact.

Mr. Scott was elected an Associate Member of the American Society of Civil Engineers, February 3d, 1897.

* Memoir prepared by the Secretary from papers on file, and from information furnished by Hartwell P. Farrar, B. M. Harrod and W. W. Hayden, Members, Am. Soc. C. E.